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Causes and Effects of Scientific Illiteracy Defined and Explored

With a lack of scientific literacy afflicting a large proportion of the U.S. population, the very survival of democracy may be at stake.

That is a problem that worries James S. Trefil, Clarence Robinson Professor of Physics at George Mason University, Fairfax, Va. He voiced this concern to an audience at a plenary session of the Pittsburgh Conference & Exposition on Analytical Chemistry & Applied Spectroscopy—Pittcon '94—held early this month in Chicago.

Trefil, who has won acclaim for several books explaining science to a lay public, cited the many controversies, public debates, and political decisions that go on in the U.S. today involving scientific and technological questions. "The idea of a citizenry ignorant of science is scary," he says. "Can a public, lacking scientific literacy, go on voting on these questions, or will there be a 'priesthood' established to decide these matters?"

Science literacy can be recognized when the public knows enough science to understand the changes occurring daily in the world, Trefil says it is similar to cultural literacy, in which "every educated person assumes a certain body of knowledge that every other educated person knows. If you don't know it, you're out of the loop."

He illustrates this point in regard to science with two cartoons from the *New Yorker* magazine. In the first, a woman tells her husband, "Your favorite sweater isn't here. I sent it out to be dry-cleaned and carbon-dated." In the second, a man entreats a woman seated on a couch with him, "Marry me, Virginia! My genes are excellent and as yet unpatented!"

The cartoonist doesn't expect the reader to know the nuts and bolts of carbon dating or the exact half-life of carbon-14, Trefil explains. But the reader must know that there is such a technique, and that it is applied to objects thousands of years old. The reader must also know roughly what a gene is, that a mention of genes is appropriate in a discussion of marriage, and that there has been a legal and ethical controversy over applying for patents on genes.

Trefil's use of magazine cartoons has another point. Public debates on issues today occur in print, he says. So to take part, a citizen must understand a daily newspaper. Universities, he says, have not done a good job of educating people to understand a newspaper. Trefil also says, though, that reading a newspaper with understanding is not a trifling task.

Part of Trefil's explanation of how the U.S. public has evolved into a largely scientifically illiterate group involves the difference between how the student sees science and how science sees itself. Scientists see science as *self-referential*, something that is preferred according to scientists' own disciplines, and as something that people do.

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That is, science is what scientists do. Also, scientists see science according to their own fields such as chemistry or physics. And the emphasis is on doing. Trefil compares the situation with a ticket taker denying a person admission to a concert unless the person demonstrates virtuosity on a violin.

To a student, however, science is problem oriented. Greenhouse gases are one such problem. To a student, science is transdisciplinary. The division of university science among traditional departments doesn't make sense to a student today. And the student's approach is appreciation rather than performance.

To describe how educators might build on this difference between scientists' and students' apprehension of science, Trefil draws an analogy from medieval European society. At that time, he says, society was divided among scholars who were literate in Latin, merchants and others who were literate in a vernacular language, and the rest of the people, who were illiterate in any language.

Thus, the science literacy that educators want to give the lay citizen may be different from, but not inferior to, that of a practicing scientist. "The emphasis should be on what the student needs to know," Trefil says, "not what the faculty wants to teach."

Trefil then raises the questions of what science should be included in the curriculum for responsible citizenship and who should teach it. He presents his own list of some two dozen concepts that he thinks might be included, such as causality, order, and Newtonian physics, as well as energy and entropy. Energy is a thread that runs through all the sciences—physics, chemistry, biology.

But there may not be enough time to cover all concepts in a long list completely. For example, at the end of Trefil's list is relativity. Does the lay citizen need to know *about* relativity? Some physicists might answer yes. But some topics in such a long list must be thrown out.

Trefil suggests that the solution is a "zero-based curriculum." Beginning with a clean slate, the educator adds topics in order of decreasing importance until the time limit is reached.

Trefil says that George Mason University is setting up such a curriculum, but skeptics ask who is qualified to teach transdisciplinary courses. They question whether a physicist like Trefil is qualified to teach biological concepts. Trefil's answer is yes. "You just have to accept that you won't be able to answer every question," he says.

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